Evaluation of ERTS-1 Imagery for Mapping Quaternary Deposits and Landforms in the Great Plains and Midwest [1] (SR 238)

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Type 1 Progress Report

ERTS-1

A. Evaluation of ERTS-1 imagery for mapping Quaternary deposits and landforms in the Great Plains and Midwest.

B. GSFC ID No. of Principal Investigator: IN 404

C. Problems encountered:

The major problem which still impedes progress on the project is the weather in the Great Plains and Midwest. Extensive cloud cover and atmospheric haze degrade much of the imagery. Some of the potential study areas still do not have complete coverage by good imagery.

D. Accomplishments during the reporting period.

The P.I. presented a paper on March 6 at the symposium on ERTS-1 investigations at the Goddard Space Flight Center, summarizing the significant findings of the project to date. The co-investigator gave a short talk about the project at the Midwest regional meeting of the Geological Society of America, in Columbia, Missouri, on 13 April. After this meeting, office and field conferences were held with personnel of the cooperating State geological surveys in Missouri, Nebraska, and Iowa.

The earlier phases of a six-phase program of analysis (outlined in the 1 January 1973 Type II report and repeated here as Appendix A) are being continued in the various study areas. Phase-1 analysis consists of interpreting landform and land-use characteristics and surficial geologic materials from the ERTS images alone, without using additional data. We adopted a basic format for the phase-1 maps and map explanations, illustrated by the maps and map explanation included with this report.

For identification and mapping of landforms, topographic information obviously is needed. In airphoto interpretation, this information is obtained most fully by stereoscopic viewing. Unfortunately, the ERTS images provide rather limited capability for such viewing, particularly in the Great Plains-Midwest. True stereovision is not provided by the 10% end-lap of consecutive frames along a track (the same scan lines appear in the overlapping areas of both frames). Stereovision is possible where frames from adjacent orbital tracks side-lap with each other; commonly 40 to 60% of a frame has such side-lap coverage. However, the limited parallax resulting from the high orbital altitude, together with the low relief in most of the Great Plains-Midwest, severely restricts the usefulness of stereoscopic viewing of ERTS images for geologic-terrain interpretation in this region. Consequently, landforms must be interpreted largely from land uses.

Land uses can be deduced from tonal (gray-level or density), pattern, and "textural" variations in the images. Landforms and landform associations are interpreted primarily from agricultural patterns, including not only field patterns, but also the patterns of pasturelands, woodlands, and rural roads. The size of fields and the regularity of their shapes (square or rectangular vs. irregular) are controlled by the topography. Concentrations of very large (greater than 160 acres) fields with regular shapes and sharp boundaries generally indicate areas of very low relief and low drainage density, such as broad flood plains and flat or gently undulating tabular uplands. The distribution of woodlands provides much information on the character of valleys and escarpments. In the areas of good soils, woodlands are restricted to slopes too steep to be farmed, i.e., the steeper valley sides. In the more arid parts of the region the steeper slopes commonly are partly woodland or brushland and partly pastureland.

Landform characteristics also can be interpreted indirectly from analysis of stream density, stream dissection and drainage patterns, and stream-divide relations--again mainly as revealed by land-use patterns, supplemented where possible by stereoviewing. It is important to make these higher levels of landform interpretation because only through them is it possible to detect anomalies that may point to the more ancient and obscure features that we are looking for, such as "palimpsests" of ancient moraines and buried river valleys. Detecting landform anomalies from ERTS images of the Great Plains-Midwest is more difficult than in regions of higher relief, less vegetative cover, and less atmospheric haze.

Interpretation of the surficial geologic materials involves secondary and tertiary levels of inference; hence, specific interpretations cannot be made at the phase-1 level, but must await the higher phases of analysis, including various kinds of "ground-truth" control. Nevertheless, some general inferences obviously can be made at the phase-1 level, for example, where the landform morphology indicates the underlying materials, as with alluvial lowlands and sand dunes.

Examples of phase-1 maps are given below.

Peoria (fig. 1) and Decatur (fig. 2), Illinois, study areas.

These two study areas are adjacent 1° x 2° quadrangles in central Illinois and are treated here as a single area. This area contains several of the classic type localities of U. S. Pleistocene geology, such as these for the Sangamon Interglaciation and the Peoria Loess. Its northeastern half (approximately) was covered by that last (Wisconsin) continental glaciation, and the remainder by an older (Illinoian) glaciation. The part glaciated in Wisconsinan time generally is less dissected by streams than the older drift plain south and west of the Wisconsin glacial limit. End moraines are well preserved on the Wisconsin drift plain, but poorly preserved on the older drift plain. The whole area has a nearly continuous mantle of loess over the glacial deposits, but the loess is highly variable in thickness.

Figure 1. Phase-1 Preliminary Map of the Peoria, Illinois, Study Area

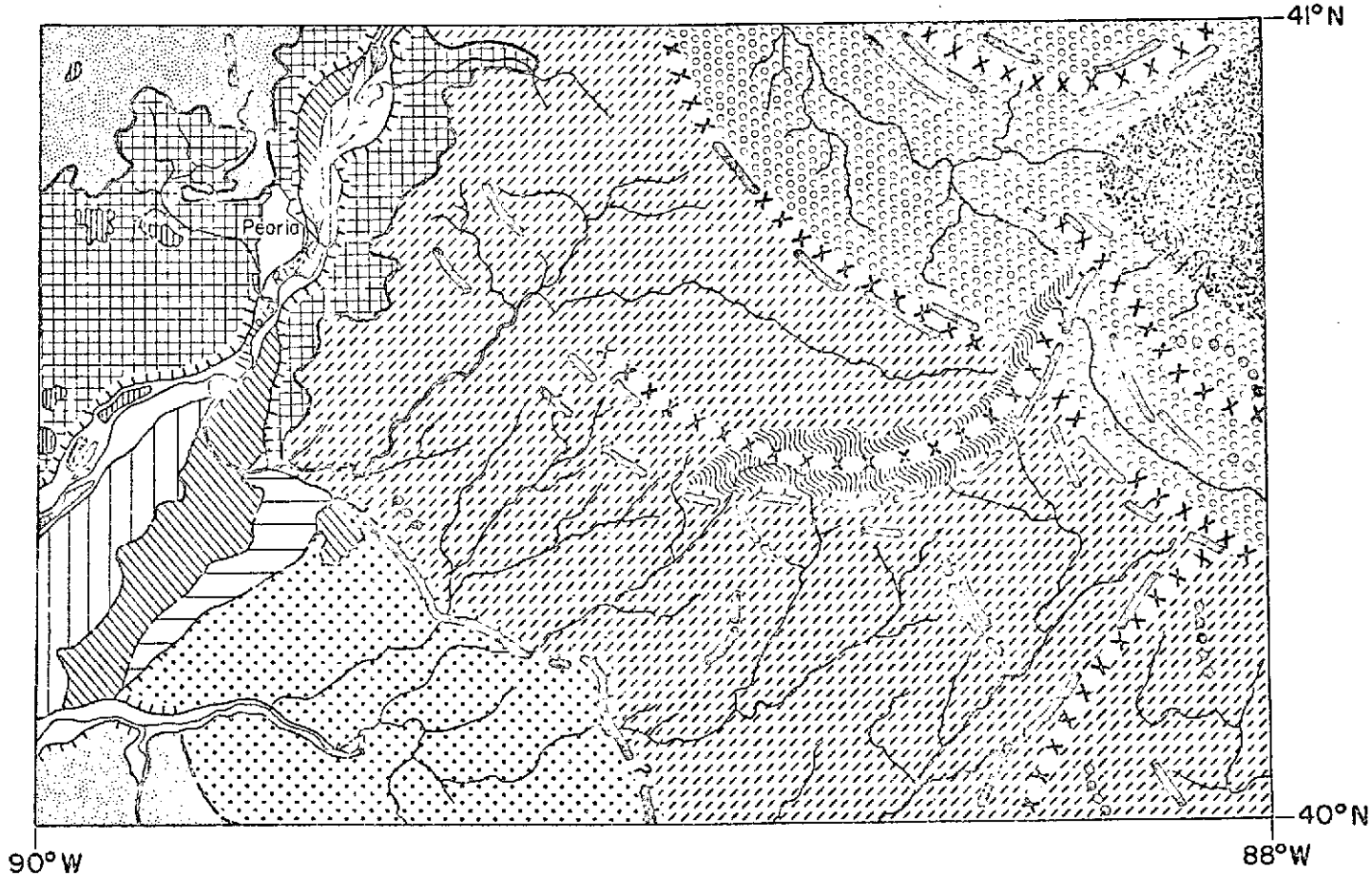
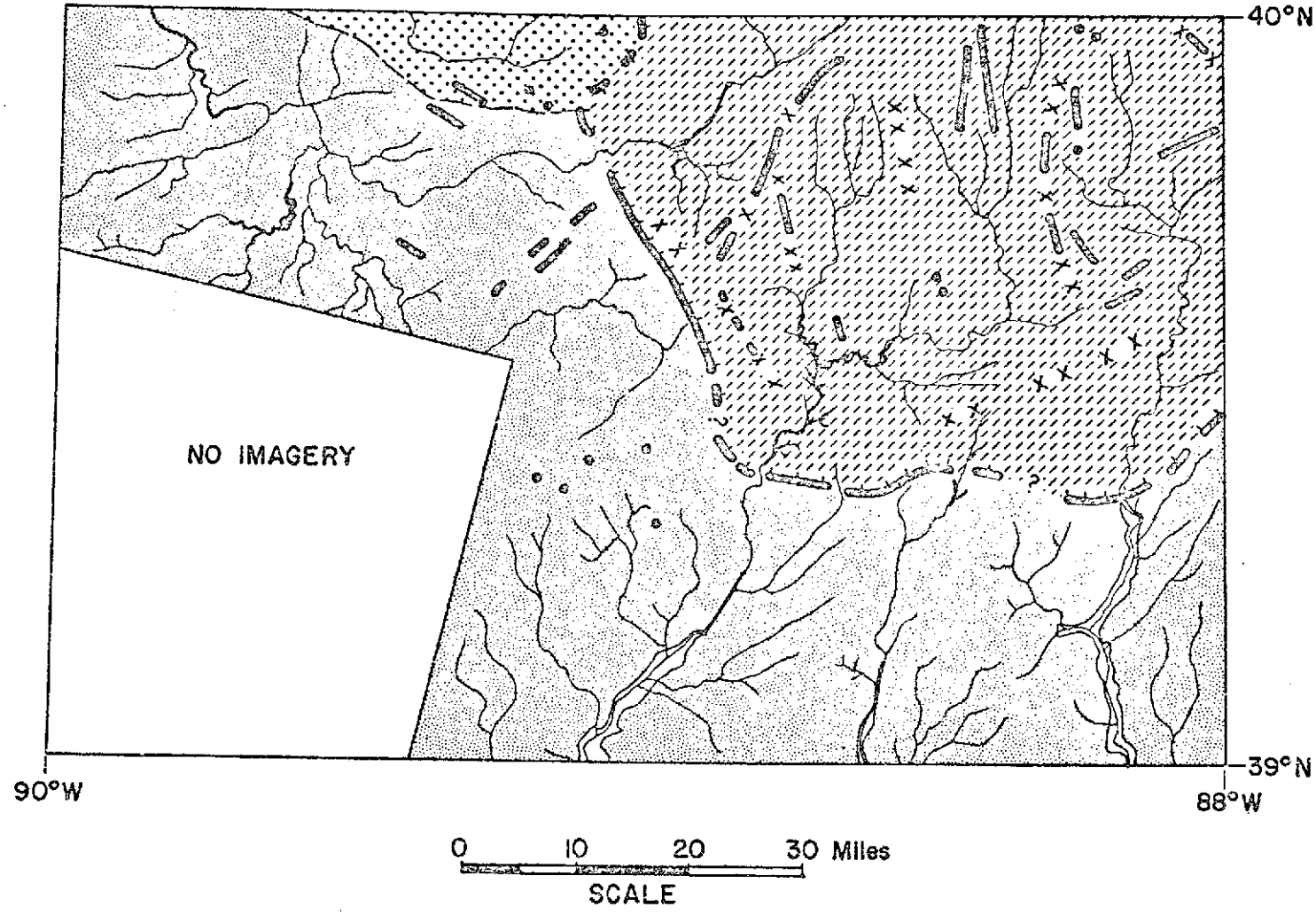
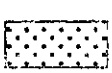
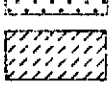
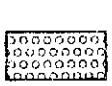
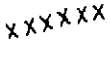


Figure 2. Phase-I Preliminary Map of the Decatur, Illinois, Study Area



Figures 1 and 2. Phase-1 preliminary maps of the Peoria and Decatur, Illinois, study areas.

EXPLANATION

Map unit	Landform characteristics	Land-use characteristics	Surficial-geologic materials
 1.	Valley lowlands: flood plains and low terraces along major streams. Single heavy lines denote minor streams with distinguishable valley lowlands.	Fields are large and regular. Mainly cropland with some pastures. Some areas of urban and industrial uses can be seen—many artificial impoundments, and a possible strip-mine or large gravel pit.	Alluvium of late Quaternary age. Higher terraces may be loess-mantled.
	Subdivisions 1a through 1c made from image 1071-16102.		
 1a.	High terrace. Mottled to intergradational gray tones may indicate sand dunes and minor swell-and-swale topography.	Fields are large and regular. The field boundaries are often not sharply defined and the intergradational tones may indicate sand dunes. One large stand of trees is present.	Alluvium, as above, and possible eolian sand and silt.
 1b.	Transition from unit 1a to unit 1c. Tones and textures indicate a mixture of areas like 1a, with possible minor sand dunes, and other areas that are like 1c, with nearly level ground and fine-grained surficial deposits.	Mixture of units 1a and 1c. Fields are large and regular. In areas like 1c the fields commonly have a wider range of tones on band 7 than in 1c. This may indicate differences in soil-drainage characteristics or in the surficial materials.	
 1c.	Level or gently sloping terrace. The area has a very uniform appearance, is higher than 1a, and may be underlain by finer textured material.	Fields are large and regular. They have a very uniform gray tone on band 7.	Alluvium, as above, and possibly loess.
 2.	Highly dissected area adjacent to the Illinois River. Streams are very closely spaced and only narrow interfluves remain.	Extensive woodlands; fields are mostly small, irregular, and scattered, although a few moderate to large size fields occur on the narrow interfluves. Mainly pasture and some croplands.	Probable extensive loess veneer over drift of Wisconsinan and older age.
 3.	Moderately dissected plains. Streams are moderately closely spaced and entrenched. The uplands are fairly broad and gently undulating. The dendritic stream pattern is much better developed than in unit 5. Topographically lower than unit 5 and probably stratigraphically lower as well.	On the uplands the fields are large to moderate in size and regular in shape; mainly cropland and some pastures. Along the entrenched streams the fields are small and irregular and mixed with extensive woodlands.	Probable extensive loess veneer over drift of Illinoian and older age.
 4.	Plains with broad undulating uplands. The streams are moderately spaced but not deeply entrenched. This unit is topographically lower than unit 5.	Fields large to moderate in size and regular in shape. The field boundaries are generally sharply defined. Some woodlands along valleys.	
 5.	Moderately dissected plains. Topographically higher than units 3 and 4; probably younger drift deposits. Streams are moderately closely spaced and become entrenched at the boundary with units 3 and 4. The interstream areas are broad and marked by probable constructional swell-and-swale topography (units 5c and 5d). Southwestern boundary is marked by abrupt entrenchment along major streams and by an escarpment, revealed by sharp changes in tone and land-use patterns.	Fields are large to moderate in size and regular in shape and are generally sharply defined. Mainly cropland and some pastures. Extensive woodlands along entrenched streams.	Probable extensive loess veneer over drift of Wisconsinan and older age.
 5a.	Mildly dissected plains. The boundary with unit 5 is the divide of the Illinois River. The streams in this unit flow away from the Illinois, and therefore they are not as closely spaced or as deeply entrenched as in unit 5.		
 5b.	Undissected plain of low relief. Few widely spaced streams in broad shallow valleys.	As above, with uniform gray tones on band 7	As above, with possible glacio-lacustrine deposits.
 5c.	Upland constructional swell-and-swale morainal topography, indicated by tonal differences in land-use patterns. Pattern used for extensive areas, heavy dash for small areas, and dots where questionable.	Fields are large to moderate in size; some have irregular shape. They are not as sharply defined as in other areas of unit 5, and are lighter in tone. The gray tones are sometimes intergradational or mottled.	Probable extensive loess mantle over drift of Wisconsinan age.
 5d.	Possible escarpment at front of moraine, interpreted from abrupt tonal and land-use changes (barbs point up-scarp).		
 5e.	Drainage pattern-stream divide relationships that suggest possible morainal trends.		
 6.	Minor streams with distinguishable valley lowlands (see unit 1).		
 7.	Minor streams without mappable valley lowlands.		
 8.	Lake or reservoir		
 9.	Strip-mined areas. Mapped from image 1036-16154.		
 10.	Prominent escarpments along valleys.		

Images used:

Peoria	Decatur
1036-16154	1070-16043
1070-16043	1070-16050
1071-16102	1071-16102
1088-16050	1088-16050
	1098-16052

The various landforms and landform assemblages, including moraines, are interpreted by phase-1 analysis of drainage patterns and tone and textural variations on the ERTS imagery. Areas interpreted as swell-and-swale moraines and morainic systems are marked by somewhat mottled and intergradational tonal patterns that are lighter than the surrounding areas. On the moraines, fields are commonly poorly defined, smaller, and more irregular than in other areas. Abrupt changes in tone and land-use patterns mark escarpments along the fronts of prominent moraines. The moraines commonly trend across minor drainages, which is indicative of constructional landscapes. (Many minor streams are mapped to show these relationships.)

An escarpment commonly marks the boundary between the Wisconsin (younger and higher) and Illinoian (older and lower) drift plains. The images show a sharp change in tones and land-use patterns at the escarpment, and, upstream from it the major streams are more deeply entrenched. Deep dissection near the Illinois River obscures the boundary west of the river in the Peoria quadrangle.

In this quadrangle, a major buried valley (probably of an ancestor of the Mississippi River) is indicated by analysis of variations in width of the valley of the Illinois River. The valley lowlands along this river are very broad north of Peoria, but they become very narrow near Peoria. South of this city they flare eastward to many times their width at Peoria; furthermore, this broad lowland is flanked on the northwest by a prominent bedrock escarpment, and a coal strip mine can be identified on the lowland close to the escarpment, indicating that bedrock here is close to the surface. These relations suggest that near Peoria the Illinois River has cut through a bedrock "high," but south of Peoria the river valley coincides, on its southeast side only, with a buried bedrock valley. The trend of the buried valley probably is northeast from this area, in line with the flare of the present valley lowland.

Other features of interest are the mapped strip-mine areas. The strip mines are easily seen on all bands of the August imagery, although they show up best on color composites. Reclaimed strip-mined areas (north of the Peoria quadrangle but known to the investigators) are easily identified.

Plans for the next reporting period.

Study and interpretation of the ERTS imagery for the various study areas within the project will continue, under the six-phase program of analysis. In addition, office and field conferences will be held with personnel of some of the cooperating State geological surveys.

E. Significant scientific results and their practical applications.

This project is testing the applicability of ERTS-1 imagery for synoptic identification and mapping of Quaternary geologic and geomorphic units ("geologic-terrain" units) in the Midwest-Great Plains, including end moraines of the last glaciation, terrace sequences along main rivers, and the effects of ancient (middle and early Pleistocene) glacial moraines and filled valleys that have been buried beneath younger glacial drift, loess, or eolian sand.

The main landform associations and larger landforms are readily identifiable on the better images and commonly the gross associations of surficial Quaternary deposits also can be differentiated, primarily by information on landforms and soils (obtained by analysis of stream dissection/drainage and stream-divide patterns, land-use patterns, etc.). Maps showing the Quaternary geologic-terrain units that can be differentiated from the ERTS-1 images are being prepared for study areas (mostly 1° x 2° in size, several in each State) in Illinois, Iowa, Missouri, Kansas, Nebraska, and South Dakota.

Preliminary maps at 1:1 million scale are given of two of the study areas, the Peoria and Decatur, Illinois, 1° x 2° quadrangles. These maps exemplify the first phase of investigations, which consists of identifying and mapping landform and land-use characteristics and geologic-surficial materials directly from the ERTS-1 images alone, without input of additional data. These maps show that commonly the boundaries of geologic-terrain units can be identified more accurately on ERTS-1 images than on topographic maps of 1:250,000 scale. From analysis of drainage patterns, stream-divide relations, and tone and textural variations on the ERTS-1 images, the trends of numerous moraines of Wisconsinan and possibly some of Illinoian age were mapped. In the Peoria study area the trend of a buried valley of the Mississippi River is revealed, mainly by analysis of changes of stream-valley widths. Strip-mined areas are easily detectable on the images, especially on color composites.

Category designation:

10, 2 a, 3 I.

F. Published articles, etc. released during the reporting period.

Hallberg, George R., 1973, ERTS-1 satellite study of Quaternary landforms and materials in the Midwest and Great Plains: a progress report (abs.): Geological Society of America, Abstracts with Programs, v. 5, no. 4, p. 320.

Morrison, R. B., 1973, Mapping Quaternary landforms and deposits in the Midwest and Great Plains by means of ERTS-1 multispectral imagery (abs.): Abstracts, NASA Symposium on Signficant Results Obtained from ERTS-1, March 5-9, 1973, Goddard Space Flight Center, Greenbelt, Md., p. 39.

G. Recommendations. None.

H. Changes in standing order forms. None.

I. ERTS image descriptor forms. None.

J. Date request forms submitted. April 30, 1973.

K. N/A.

Appendix A

The six-phase program of interpretation of ERTS-1 data that is scheduled for this project:

Phase 1 consists of preliminary mapping of the pertinent geologic and geomorphic features using only the ERTS-1 imagery.

Phase 2 involves compilation of available published and unpublished ground truth data (geologic, soil, topographic, etc.), preferably on a map of the same scale as that prepared for phase 1, without using ERTS data.

Phase 3 is a comparison of phase 1 and 2 products, with additional photointerpretation, to prepare an "enhanced information" map (at scales ranging from 1:1 million to 1:250,000, as appropriate), noting any differences and anomalies.

Phase 4 consists of additional analysis made from ERTS repetitive coverage of the area, noting added information (at least the differences in information content) gained from time-variant phenomena such as changes in vegetation, soil moisture, snow cover, and plowing of croplands.

Phase 5 consists of appropriate field studies to obtain necessary additional ground-truth data, particularly to evaluate anomalies and interesting new features found in phases 3 and 4.

Phase 6 is the delineation of the new information detected from the ERTS imagery.